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SEED POTATO CERTIFICATION IN PENNSYLVANIA

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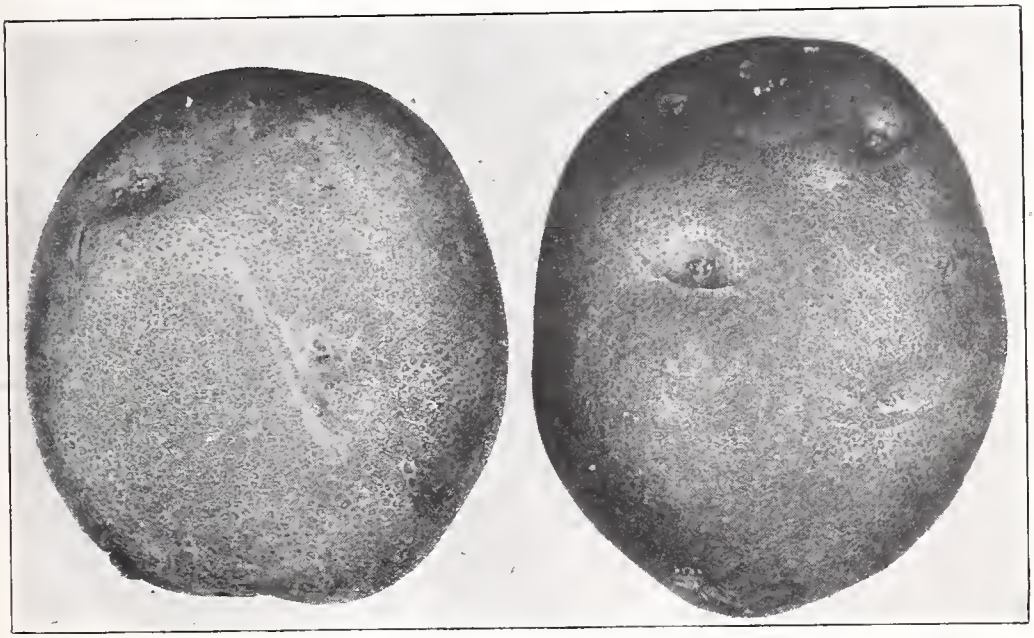

Typical Certified Russet Rural Potatoes

F. P. WILLITS, *Secretary of Agriculture*
C. H. HADLEY, *Director, Bureau of Plant Industry*

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SUMMARY

What is the Aim of Seed Potato Certification?

To produce perfect seed potatoes.

What is a Perfect Seed Potato?

(1) It is of a standard commercial variety.
(2) It is free from other varieties.
(3) Its tubers are nearly uniform in size.
(4) Its shape conforms to the accepted type.
(5) It has inherent vigor of growth.
(6) It is of a high yielding strain.
(7) It has been freed by selection, spraying, rogueing, and sorting from virus diseases, Rhizoctonia, Scab, Wilts, Blackleg, Rots, Blight, and surface imperfections.
(8) It has been kept over winter under good storage conditions.

Where Can I Get Perfect Seed Potatoes?

No absolutely perfect stock is known to exist in the world. In commercial channels the nearest approach to it is found in **certified seed.**

Why is Certified Seed Ranked as the Best Obtainable?

Because it has back of it the best results of past experience as well as the best scientific methods of a scientific age.

It is in the potato industry what carefully bred stock is in the dairy industry.

What Advantages Does Certified Seed Offer to the Potato Grower?

If grown under favorable conditions he may expect a uniform stand of healthy vigorous plants which will set well, yield well, and give a crop of shapely tubers that will grade with minimum loss.

Where Can Certified Seed Potatoes be Procured?

The Department of Agriculture publishes a list each year of the growers of certified seed in Pennsylvania. Write or ask for it.

How Can I be Sure That What I Will Get is Actually Certified Seed and Not Some Substitute?

Certified seed may be obtained in bags tagged and sealed before shipment, thus assuring the buyer of the genuineness of the article, even if it comes from an unknown grower or comes indirectly through a seed firm.

Seed Potato Certification in Pennsylvania

By W. A. McCubbin, R. E. Hartman and K. W. Lauer

Bureau of Plant Industry

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SEED POTATO CERTIFICATION IN THE UNITED STATES

Seed production under a definite standard and system of field and tuber inspection was first established in Wisconsin in 1913. Since that time the number of states engaged in seed potato certification has steadily increased. At the time of this writing (1925), seed certification is conducted in twenty-four states of the United States and in several provinces of Canada. This represents practically all of the late potato producing areas in the northern half of the United States and the Canadian Provinces. The amount of seed produced in the United States during the first five years following the inauguration of a certification system by Wisconsin was small; in fact it had reached less than one-half million bushels by 1920, but after that year the growth of the industry was so rapid that a production of over seven million bushels was reached during the season of 1924.

SEED POTATO CERTIFICATION IN PENNSYLVANIA

Seed potato certification was established in Pennsylvania by the Pennsylvania Department of Agriculture in the year 1920. The first two years were devoted entirely to a survey of the principal potato producing sections of Pennsylvania to determine whether there were sections of our potato areas suitable for seed potato production. As a result of this survey, it was found that certain counties, i. e., Bradford, Cambria, Potter, Somerset and Sullivan,

all located in the higher altitudes with their attendant short growing seasons, were especially endowed for seed production. Within these areas it was found that though diseases of the degenerate and transmissible type were present, their percentage average was very low, only about one-third of the average of the twenty-five thousand acres surveyed in all parts of Pennsylvania. Within these areas, which extend from the north central to the south central part of Pennsylvania, the production of certified seed was actually begun in 1922 with a definite standard and regular inspection service.

The main purposes of seed certification in Pennsylvania were twofold. First, to produce an adequate supply of good certified seed grown in various sections of Pennsylvania, and second, to produce potato wart immune varieties of seed potatoes, free of mixtures and of high yielding and disease free qualities, to be used in controlling or eradicating the potato wart menace now firmly though not widely established in the anthracite and bituminous coal regions of Pennsylvania. The amount of such seed needed is small as yet but a considerable supply would be required should the disease spread to any of the large potato sections. This phase of the work can be expanded at any time should the need arise since the areas now growing certified seed could, within a very short time, supply wart immune certified seed in large quantities.

Our efforts, then, are now mainly directed to producing for commercial consumption, first, varieties of seed potatoes of even higher quality than heretofore; second, to include all commercial varieties grown in Pennsylvania so as to furnish seed for all needs or purposes; and third, to increase the supply of seed as the demand arises.

The need of good, cheap and reliable seed grows more apparent each year as the relationship of seed to the cost of production is more generally understood. In fact, potato production has now reached the point where, unless the cost per bushel can be lowered, the average grower will be forced to stop growing potatoes or grow them at a loss. Good seed will help the grower to produce potatoes at a profit instead of a loss, provided he can secure such seed at a reasonable price. Though the quantity of the certified seed now being produced is large, the cost remains relatively high, due largely to high transportation costs. It is expected that by producing seed within the state the cost of transportation will be reduced to a minimum, thereby considerably reducing the cost of seed to the grower.

During 1924, twenty-three potato growers in 16 different

counties of the state reported an average increase in yield of 32.9 bushels to the acre from the use of Pennsylvania certified seed, as compared to home grown seed. The average yield reported was 210.8 bushels from certified seed and 177.9 bushels from home grown seed. Many other growers reported satisfactory results from the use of certified seed. These results are not taken from experimental reports, but are actual returns secured by practical potato growers whose opinions and estimates are the final word as to whether or not it pays to plant certified seed potatoes.

INSPECTION AND CERTIFICATION STANDARDS

Number and Time of Field Inspections:—The certified seed standards call for three field inspections: The first inspection is made when plants are 8″ to 10″ high, the second inspection at blossoming time and the third or final inspection follows the final rogueing, but this inspection must be made before the plants lose their vigor as a result of maturity, frost, etc.

The first inspection is made as early as possible, thus permitting the grower to rogue his field early and thereby avoid the possibility of having diseases transmitted to healthy plants. The second inspection, which occurs at blossom time, insures the detection of any mixtures present and serves as a check on the thoroughness of the grower's first rogueing. The third and final inspection is very important, for at this time all diseased plants remaining in the field are removed by the grower in the presence of the inspector before the stock is certified.

Basic Requirements:

(1) Only standard commercial varieties will be considered for seed production.

(2) Potatoes for certification must be grown from stock that has been previously certified or approved.

(3) New strains may be certified after testing for one year in comparison with known certified stock.

(4) Seed potato production will be encouraged only in counties or districts which have proven themselves capable of producing good seed.

(5) Conditions under which seed potatoes should be grown include good culture, which implies crop rotation, good tilth, freedom from weeds and the control of diseases and insects by proper spraying.

(6) All fields entered for certification will be rogued immediately following first inspection and twice thereafter, the final rogueing to precede third inspection.

Field Inspection Requirements:

First Inspection (given before rogueing).

Fields will be disqualified which contain more than the following percentages of disease, or more than 6% of all these diseases combined: Leaf Roll, 5%; Mosaic, 3%; Spindle Tuber, 3%; Curly Dwarf, 1%; Blackleg, 2%; Wilt, 2%.

Second Inspection (after first rogueing).

Only the following tolerances will be permitted: Leaf Roll, 2%; Mosaic, 2%; Spindle Tuber, 1%; Curly Dwarf, 1%; All the above virus diseases, 3%; Wilt, 2%; Blackleg, 1%; All diseases combined, 4%; Weak plants, 2%; Varietal Mixtures, 1%.

Third Inspection (to follow final rogueing, including extra rogueing for Giant Hill).

Tolerances: Leaf Roll, Mosaic, Spindle Tuber and Curly Dwarf, combined, 1%; Giant Hill, 2%; Wilt, 1%; Blackleg, 1%; All diseases, 2%; Weak plants, 1%; Varietal mixtures, .25%.

Late Blight, if present, should be recorded, and if serious enough to obscure other troubles the field will be disqualified. The crop from fields showing Late Blight will be given certification for spring shipment only.

Grading Standards.—Under authority of the Markets Act the Department of Agriculture established on March 15, 1926, grades for certified seed potatoes, the requirements for which are as follows:

Pennsylvania Certified Seed Grade

This grade shall include only potatoes which have passed the field inspection requirements of the Bureau of Plant Industry.

Potatoes showing black heart, or excessive sweating, sprouting or shriveling, indicating improper storage, shall not be allowed in this grade.

This grade shall consist of potatoes of one variety which are practically free from dirt or foreign matter, sunburn, second growth, growth cracks, cuts, bruises, mechanical injuries, severe scab, severe insect injuries, or other defects, provided that the total of all potatoes showing such defects shall not exceed 2% by weight.

The potatoes in this grade shall be free from disease or insect injury, provided the following tolerances, by weight, are not exceeded:

Common scab—5% of moderate infection.
Rhizoctonia (Black Scurf)—10% of moderate infection.
Stem end discoloration—5%.
Spindle tuber—1%.
Powdery scab—no tolerance.
Wireworm injury—10%, of which not more than half shall consist of moderate injury.

The potatoes in this grade shall be free from rots and freezing injury, provided that a tolerance of 2% is not exceeded.

The potatoes in this grade must comply with one of the following size requirements, provided that the tolerance of 3%, by weight, above or 1% below these size requirements is not exceeded:

"Standard Size"—minimum diameter 1⅞ inches, maximum weight 12 ounces.

"Small Size"—Minimum diameter 1½ inches, maximum diameter 1⅞ inches.

"Combination Size"—Minimum diameter 1½ inches, maximum weight 12 ounces, provided that at least 50% by weight shall exceed 1⅞ inches in diameter.

Pennsylvania Field Certified Seed Grade

This grade shall consist of potatoes which have passed all field inspection requirements of the Bureau of Plant Industry, but which may not have been graded or sized according to the requirements of the "Pennsylvania Certified Seed Grade."

Definition

1. "Dirt" refers to adherent mud, earth, or caked soil.
2. "Foreign Matter" refers to stones, vines, leaves, soil or other objectionable material.
3. "Sunburn" refers to greenish discoloration which will not disqualify if confined to small areas of the tuber.
4. "Second Growth" refers to the secondary tuber development which has caused misshapen stock.
5. "Growth Cracks" refers to growth fissures other than those which are shallow and well healed.
6. "Rots" refers to all dry and wet rots in any stage of development.
7. "Freezing Injury" refers to frozen tissue or tissue showing the effects of having been frozen.

8. "Moderate Injury or Infection"—In the case of rhizoctonia, slight infection will be disregarded; the term "moderate infection" shall be construed to mean that less than 5% of the surface is covered by sclerotia.
In the case of scab, slight infection is disregarded; "moderate infection" shall be construed to mean surface scab, the aggregate area of which shall not exceed 10% of the area of the tuber.
In the case of wireworm injury, "moderate injury" shall be construed to mean from three to ten healed wireworm holes per tuber.

9. "Stem End Discoloration" refers to dark streaks in the flesh radiating from the stem, which penetrate more than ¼ inch from the surface.

IMPORTANT FACTORS IN PRODUCTION

Selection of Seed Areas.—The production of good seed is only possible in sections favored by a short cool growing season, for it is only in such areas that the potato plant maintains a continuous vegetative growth and thus makes easy the identification of diseases of the degenerative type and so facilitates thorough roguing. Another and equally important factor in selecting a seed area is the presence or absence of insects which spread disease. It is practically impossible to produce good seed unless these insects are absent; at least they should not occur in numbers until late in the season, thus permitting the fields to be thoroughly rogued prior to their appearance.

Areas of this kind are to be found in some part of practically every late potato producing state of the United States and are now being developed as seed centres for the production of certified seed.

Seed Requirements.—One of the basic requirements established for the growing of certified seed is that the potatoes entered for certification must be grown from previously certified or approved stock. This is very important and desirable for only seed stock that has proven its high yielding qualities and disease freedom over a period of years can be relied upon. In addition, as certain strains of each variety prove their superiority they are adopted as the basic strain for certification of that variety and in this way the seed stock is continually improved.

Growers are encouraged to practice hill selection and seed plot testing of such selections as a means of improving their individual seed stock and as such selections prove their superiority they are

adopted as a basic stock of the variety and given a strain name, usually the name of the grower.

Isolation of Seed Fields.—It is strongly recommended that seed fields be isolated, that is, stock intended for seed should not be planted in the same field with the commercial crop. If the seed field is part of the same field devoted to the commercial crop, then a barrier of not less than five rows should be rogued in addition to the regular amount required for seed. These five rows should be given the same treatment as the regular seed field but at digging time they should be included in the commercial crop instead of the seed crop. The purpose of this is to prevent the spread of some of the common virus diseases from the unrogued commercial crop to the rogued seed crop. Such diseases as leaf roll and mosaic are spread by aphids or sucking insects from diseased plants to normal healthy plants. Aphids are very sluggish and slow moving insects and therefore their natural range of movement in one season is limited. However, even a barrier of five rows will not suffice to prevent their spread by wind and other means. For this reason the safe precaution is to isolate the seed field or if part of the commercial field is used to rogue the entire field.

Culture.—The grower of certified seed must practice good culture; this implies the proper preparation of the seed bed, clean cultivation, proper fertilization and a rotation which reduces or eliminates the danger of infection from soil borne organisms.

The seed bed if properly prepared by deep plowing, thorough disking and harrowing will have a loose soil, free from lumps and sod clots, which permits the planting of potatoes at an even and proper depth. Proper preparation also conserves moisture, which stimulates an even and rapid germination. This is very important in the eyes of an inspector, as fields with an uneven germination rarely, if ever, pass the first field inspection.

The proper amount or kind of fertilizer must be determined by the grower, but the fertility supplied must be sufficient to keep the plants in a continuous and luxurious vegetative growth up to the time of natural death or frost. Fields that are checked in growth or turn yellow prematurely as a result of improper fertilization are refused certification, because in such fields diseases might be present but unrecognizable as a result of this condition.

The control of weeds by proper cultivation is necessary, for weedy fields harbor insects, prevent proper spraying and often stunt the growth of plants.

In determining the proper crop rotation, careful attention must be given to the importance of soil diseases and insects. In the matter of soil diseases, these can be controlled if the rotation is sufficiently long and the question of soil reaction and drainage are properly cared for. Common scab, the worst of our soil borne organisms, is controlled easily in a neutral or slightly acid soil, provided the soil has sufficient humus to keep a fairly high water content, as scab is especially severe in dry soils. In some cases it may be necessary to resort to artificial means to reduce the alkalinity of the soil, but this should rarely occur if proper attention is paid to liming and the application of manures in the rotation.

Fig. 1.—Wire worm injury.

Insects, such as the grub worm and wire worm, become very severe if old sods are used for potatoes and the only practical method of controlling insects in such fields is to practice fall plowing; in fact it is a safe precaution to practice fall plowing in even one year old sods.

POTATO VARIETY CLASSIFICATION

The necessity of maintaining certified seed potatoes free of varietal mixtures requires a definite description or classification of the common commercial American varieties.

The common practice of many growers and seedmen of giving

a new name to each new strain they are propagating, as a means of identification, has resulted in hundreds of named varieties of potatoes. However, a careful study of the vine, flower, tuber and sprout characters of the common commercial American varieties permits them to be separated into twelve distinct variety groups, with a subdivision of a few groups when the tubers show distinct differences in shape and color. These groups are distinguishable from each other by constant and definite characters, but within the group the many named varieties are not distinguishable and should be referred to as strains of the variety if special identification is desired. In this connection it might be well to caution the grower that these special named strains have no distinguishing characters and identification is only possible from personal knowledge or certified records.

Fig. 2—Left: Black scurf (Rhizoctonia) on the surface of a tuber. Right: A tuber badly affected by common scab.

The key to potato varieties which follows is not perfect but it does serve as a practical guide in determining varieties in the field. To illustrate its use we will assume that the variety being identified has a colored flower, which places it immediately in group 1, 2, 3, 4 or 5. If we examine the tubers it will be possible to further reduce the number of groups to which the variety may belong. Assume that the tubers are white skinned and the variety must belong to either group 1 (section II), group 2 or group 3. At this point it will be necessary to refer to the flower

character for final identification. The Cobbler flower being a rose-lilac, the Rural purple and the Up-To-Date rose-purple, the variety can be identified by determining the flower color. After the variety has been identified by the use of the key it is advisable to read the full group description which follows the key as a check to the identification.

Following each group are listed the common named varieties or strain synonyms which belong in it. In addition these synonyms are subdivided into those which are immune and susceptible to the potato wart disease.

I. COLORED FLOWER GROUP.

A. Tubers creamy white or russet.

1. Tubers russet—Flowers purple ..Group 1 Sec. II — RURAL
2. Tubers creamy white
   a. Flower rose-lilac .....Group 2 — COBBLER
   b. Flower rose-purple .....Group 3 — UP-TO-DATE
   c. Flower purple .....Group 1 Sec. I — RURAL

B. Tubers red or carmine.

1. Tubers red—Flowers light rose-purple .....Group 4 — TRIUMPH
2. Tubers carmine (Streaked)—Flowers rose-purple .....Group 5 — PEACHBLOW

II. WHITE FLOWER GROUP.

A. Tubers red, pink or flesh colored.

1. Tubers cylindrical and red .....Group 6 — EARLY OHIO
2. Tubers spindle shape
   a. Tubers pink .....Group 7 Sec. I — ROSE
   b. Tubers flesh colored .....Group 8 — HEBRON
3. Tubers broadly flattened and pink Group 7 Sec. II — ROSE

B. Tubers russet or creamy white.

1. Tubers russet .....Group 9 Sec. I — BURBANK
2. Tubers creamy white
   a. Tubers roundly flattened ....Group 10 — EARLY MICHIGAN
   b. Tubers cylindrical .....Group 9 Sec. II — BURBANK
   c. Tubers heart shaped .....Group 11 — PEARL
   d. Tubers oblong or roundly flattened .....Group 12 — GREEN MOUNTAIN

COLORED FLOWER GROUP

GROUP 1. RURAL.

Maturity.—Late.

Vines.—The vines of this variety are very distinct in their early habit of growth. The primary stem is upright, long jointed and sparingly covered with foliage, the lateral branches more or less decumbent, giving the plant a straggly appearance. Stems distinctly streaked with purple. Leaves small, dark green, more or less rugose or crumpled and leathery to the touch.

Flowers.—The central portion of the corolla is deep purple, gradually shading to a lighter tone toward the periphery. The color is usually absent on the upper side of the five points of the corolla. Flowers medium in size and fairly abundant.

Tubers.—Tubers round flattened to oblong flattened or broadly roundish oblong flattened. Eyes few, very shallow, but very strong. Skin creamy white or slightly netted in Section I, and russet in Section II.

Sprouts.—Sprouts are short and enlarged at the base. The base of the sprout is colorless, but the tip and leaf scale are deeply tinged with purple-violet or pansy-violet.

Varietal Synonyms.—All susceptible to wart.

Section I

Rural New Yorker
Rural New Yorker No. 2
Noxall
Million Dollar
Number 9
Carman No. 3
Sir Walter Raleigh

Section II

Late Petoskey
Dibble's Russet
Kasoag's Russet

GROUP 2. COBBLER.

Maturity—Early.

Vines.—Vines medium to above medium in size, with a bushy and slightly spreading habit of growth. The stems are stocky and short jointed, dark green in color, with a reddish purple band above the nodes. The leaves are large, flaccid and dark green in color.

Flowers.—Flowers rose-purple or rose-lilac. Flowers numerous and rather large. (Note) Under intense heat the color may be entirely unexpressed.

Tubers.—Tubers roundish with blunt ends, the stem end often notched deeply, giving a shouldered appearance to the tuber. The eyes are medium in number, shallow to very deep, particularly in the bud cluster. Skin smooth and of a light creamy white color.

Sprouts.—The sprouts are rather short and stubby and colored a reddish-violet at the base. The leaf scales and tips are similarly colored.

Varietal Synonyms.—All immune to wart: Irish Cobbler, Early Eureka, Early Petoskey, Early Victor, Potentate, Flour Ball, etc.

GROUP 3. UP-TO-DATE.

Maturity.—Late.

Vines.—Vines upright, spreading and very branched. The plant has a strong central upright stem with extra long leaf petioles. Stem very stocky and of an olive green color, sparingly tinged with purple pigment. Leaves large, decidedly rugose, thickened in appearance and olive green in color.

Flowers.—Flowers rose-red. Flowers numerous and large. The flower stalk is very large, long and slightly flattened.

Tubers.—Tubers roundish oblong to flat oblong. Eyes medium in number and depth. Skin creamy white to white.

Sprouts.—Sprouts vase shaped, being slightly enlarged at the base. The base of the sprout is colorless, but the leaf scales and tip are colored a dull mauve.

Varietal Synonyms.—All susceptible to wart: Cumming's Pride, Up-to-date, Witcomb, Davie's Warrior, and Cummings.

GROUP 4. TRIUMPH.

Maturity.—Extra early.

Vines.—Vines very compact with a bushy or dwarf habit of growth. The stems are short jointed and stocky and colored a dark green with a reddish-purple pigment throughout the stem and leaf petioles. Leaves medium large and dark green, with thickened rugose appearance.

Flowers.—Flowers light purple. Flowers small. (Note) This variety rarely blooms.

Tubers.—Tubers round with blunt to obtuse ends, slightly shouldered at the stem end. Eyes medium in number and deeply set at the bud cluster. The skin is creamy-white or slightly marked with pink about the eyes, (i. e., White Triumph) or deep red or carmine (i. e., Bliss Triumph).

Sprouts.—The sprouts are medium in size and slightly enlarged at the base. The base, leaf scales and tip are colored a reddish-violet.

Varietal Synonyms.—All susceptible to wart: Quick Lunch, White Triumph, Bliss Triumph, Norton Beauty.

GROUP 5. PEACHBLOW.

Maturity.—Most varieties late, a few early varieties, i. e., Extra Early Peachblow.

Vines.—This variety is noted for its extremely large and vigorous vines. The vine has a large central upright stem. Stems long jointed and very woody and medium to light green in color. The leaves are medium in size and number and of a darkish green color. The leaf petiole is very long.

Flowers.—Flowers rose-purple. Flowers are very large and numerous The flower stalk is very long and flattened in shape. (Note) These varieties usually set fruit if conditions are favorable.

Tubers.—Tubers round or round oblong and usually irregular in shape. The eyes deep set and fairly numerous. The skin is creamy-white with splashes of carmine about the eyes, or crimson.

Sprouts.—Sprouts short and stubby with the base bulbous. The base, leaf scales and tip are colored a reddish-violet.

Varietal Synonyms.—All immune to wart: Improved Peachblow, McCormick, Jersey Peachblow, Early Peachblow, Extra Early Peachblow, Round Pink Eye, White McCormick, and Red McCormick.

WHITE FLOWER GROUP

GROUP 6. EARLY OHIO.

Maturity.—Early.

Vines.—The vine is often described as resembling the Early Rose group, but the similarity does not prevent distinction. The vine has a decided upright habit of growth, with a very heavy, long jointed, dark green stem, markedly tinged with reddish-purple pigment. The leaves are large and roundish and of a darker green than the Early Rose. The veins of the leaf and petiole are tinged with red.

Flowers.—Flowers white. Flowers numerous and fairly large.

Tubers.—The tubers are roundish cylindrical with full rounded stem and eye ends. The eyes are numerous and shallow. The skin is pink, except the White Early Ohio. The surface of the tuber about the eye end is covered with corky growths (lenticels). This is characteristic of the variety.

Sprouts.—The sprouts are short and very much enlarged at the base. The base, leaf scales and tip are colored a carmine-lilac to rose-lilac.

Varietal Synonyms.—Wart immune: Early Ohio, Early Market, Early Six Weeks, Late Ohio, and White Ohio.
Wart susceptible: (None).

GROUP 7. ROSE.

Section 1. Early Rose.

Maturity.—With the exception of Late Rose, all varieties under this group are early to extra early in maturity.

Vines.—Vines of medium height and with stout, erect dark green stems. The stems are highly tinged with reddish-purple. The leaf habit is very characteristic in this group, appearing somewhat like the sumac leaf. The leaves are very regular in shape, slightly elongated and pointed and of medium dark green color. The veins of the leaf petiole and of the leaf are colored a reddish-purple.

Flowers.—Flowers white. Medium in size.

Tubers.—Tubers are decidedly elongated and slightly flattened at the center, tapering gradually to both stem and eye end, and with rather blunt ends. Eyes usually numerous and sharply defined, medium to deep, but at times protuberant. Skin smooth and with the exception of White Rose, is pink to reddish in color. The tubers are more deeply tinged than the Early Ohio varieties. Flesh white, but occasionally streaked with red.

Sprouts.—Sprouts long and slender with the base only slightly enlarged. Base tinged with rose-lilac. Tips and leaf scales creamy-white or only slightly tinged with rose-lilac.

Varietal Synonyms.—All susceptible to wart: Early Rose, Early Maine, Late Rose, and Extra Early White Rose.

GROUP 7. ROSE.

Section II. Spaulding Rose.

Maturity.—Medium late to late.

Vines.—Similar to Section I; however, the vines are larger and more thrifty in growth.

Flowers.—Flowers white. Rather abundant and large.

Tubers.—The tubers are broad, oval oblong and distinctly flattened. The eyes are few and very shallow. The skin is colored a deep pink or red.

Sprouts.—Sprouts short and stubby and decidedly enlarged at the base. Base, tips and leaf scales are colored a rose magenta.

Varietal Synonyms.—All immune to wart: Spaulding Rose, Early Manistee, Late Manistee, and Northern King.

GROUP 7. ROSE.

Section III. Seneca Beauty.

Maturity.—Early.

Vines.—Vines very similar to the Early Rose, but some varieties, i. e. Seneca Beauty, have a spreading rather than the upright habit of growth.

Flowers.—Flowers rose-lilac or purple-lilac. Flowers small and compact.

Tubers.—Tubers oblong, rather broad and thick, more or less flattened and usually large. The eyes are deep set and deeply colored. Skin a deeper red than Early Rose.

Sprouts.—The sprouts are short and stubby with the base, leaf scales and tip colored a deep rose-lilac or magenta.

Varietal Synonyms.—Susceptible to wart: Seneca Beauty, Extra Early Red Rose, Old Early Rose, and Lee's Favorite.

GROUP 8. HEBRON.

Maturity.—Medium early.

Vines.—The size, color and shape of the vines and stem of these varieties resemble the Early Rose; however, the vines are less branched, giving it a scanty growth appearance. The veins of the leaf and petiole are tinged with reddish pigment.

Flowers.—Flowers white. Flowers medium to large.

Tubers.—The tubers are elongated and somewhat flattened with blunt ends, at times spindle shaped. The eyes are numerous and of medium depth. The skin is flesh colored, very intense about the eyes.

Sprouts.—The sprouts are long and only slightly enlarged at the base. The base, tip and leaf scales are tinged with rose-lilac.

Varietal Synonyms.—All susceptible to wart: Early Beauty of Hebron, Early Bovee, Late Beauty of Hebron, Country Gentleman, and White Elephant.

GROUP 9. BURBANK.

Maturity.—Medium early to late.

Vines.—The vines are bushy, medium in size, markedly branched and spreading. Stems light to medium green and stocky, only slightly tinged with reddish-purple pigment. The leaves are very abundant, medium in size and of a dark green color.

Flowers.—Flowers white. The calyx cup has a sooted appearance.

Tubers.—

Section I. Tubers long, cylindrical or slightly flattened in shape. eyes numerous, evenly distributed and very shallow. The skin is smooth and creamy-white in color.

Section II. Tubers same as Section I, the only difference is in the color and texture of the skin. In Section II the varieties are russet skinned, heavily netted or reticulated.

Sprouts.—Sprouts short and slightly bulbous. The base, tip and leaf scales are tinged with magenta.

Varietal Synonyms.—

SECTION I.

Immune to wart: Burbank and White Beauty.
Susceptible to wart: Money Maker.

SECTION II.

Immune to wart: Russet Burbank.
Susceptible to wart: Netted Gem, Scabproof, and California Russet.

GROUP 10. EARLY MICHIGAN GROUP.

Maturity.—Early to medium early.

Vines.—The vines are of medium size with an upright spreading habit of growth. The stems are medium to dark green in color and sparingly tinged a reddish-purple. The leaves are medium in size and a medium dark green color.

Flowers.—Flowers colored white. The surface of the calyx cup in green (not sooted).

Tubers.—Tubers oblong flattended to elongate flattened. The skin is normally white. Some varieties have a pink tinge about the eyes in the bud eye cluster. This tinge disappears soon after digging.

Sprouts.—Sprouts slender with a slightly bulbous base. The base is colored a rose-purple with the tip and leaf scale colored a creamy-white or a faint tinge of rose-purple.

Varietal Synonyms.—

Immune to wart: White Albino, Extra Early Sunlight, Extra Early Sunlight, and Early Harvest.
Susceptible to wart: Early Albino, Early White Albino, Early Puritan, Early Sunrise, and White Hebron.

GROUP 11. PEARL.

Maturity.—Late.

Vines.—The vines are medium in size, strong and vigorous. The central stem is horizontal with upright branching, these branches becoming decumbent as the plant reaches maturity. The stems are stocky

and very dark green in color. (The Blue Victor is streaked with purple.) The leaves are medium large, wrinkled and dark green, especially as the plant nears maturity.

Flowers.—Flowers white, few and medium large.

Tubers.—Tubers are round to heart shape flattened. Usually heavily shouldered and broader at the stem than eye end. Eyes shallow, usually clustered about the eye end. When first harvested the Pearl and People's have a faint pink tinge about the eyes in the eye cluster. This tinge soon fades and disappears. The skin is slightly netted and creamy white. (Exception: The Blue Victor is colored a violet blue and the skin is reticulated.)

Sprouts.—The sprouts are short and slightly bulbous. Base, tip and leaf scales tinged a light rose-purple. (Exception: Blue Victor, base, tip and leaf scales colored a vinous mauve.)

Varietal Synonyms.—

SECTION I.

Immune to wart: (None).
Susceptible to wart: Pearl and People's.

SECTION II.

Immune to wart: (None).
Susceptible to wart: Blue Victor.

GROUP 12. GREEN MOUNTAIN.

Maturity.—Late.

Vines.—The vines are large to extra large, strong, vigorous and well branched. The stems have an upright habit of growth when young, but on nearing maturity they assume a spreading habit of growth. Some varieties becoming distinctly decumbent. The stems are long jointed, light green in color and are usually entirely free of the reddish-purple pigment so common in most varieties. Leaves medium in size, numerous and of a light green color.

Flowers.—Flowers white, abundant and large.

Tubers.—The tubers are roundly flattened to oblong flattened with blunt ends, especially the eye end. Eyes medium in number and fairly deep. Skin a creamy-white and slightly netted with small russet scales, especially noticeable near the eye end.

Sprouts.—The sprouts short and stubby with a slightly bulbous base. Sprouts are colorless in Section I. Section II, the base is colorless, but the tip and leaf scales are tinged a light purple-lilac or magenta.

Varietal Synonyms.—

SECTION I.

Immune to wart: Green Mountain, Green Mountain Jr., Norcross, Gold Coin, Snow, Uncle Sam, and Empire State.
Susceptible to wart: Carman No. 1 and State of Maine.

SECTION II.

Immune to wart: Idaho Rural, Charles Downing, Rust Proof, American Giant.
Susceptible to wart: (None).

DISEASE AND INSECT CONTROL

The losses incurred by Pennsylvania potato growers through such diseases as can be controlled through the use of improved seed range from 20 to 25 per cent of the total annual crop. These losses mean that for every 10 acres of potatoes produced, approximately two acres must be grown without any return to the grower. This unnecessary waste of time, labor and materials is all the result of planting poor seed and could be avoided by using certified seed.

Certified seed may not always give good returns, but in the majority of cases it will be found to be far superior to any other seed obtainable. Purchasers of certified seed are also warned not to expect the resulting crop to be entirely free from disease. It is practically impossible to produce any potatoes that are absolutely disease-free; and even though such stock is as clean as it is possible to make it, a small amount of diseases will be found in the resulting crop. Such stock may also become infected because of being planted on a badly infected soil, or through infection carried from adjacent diseased stock.

Freedom from disease and increased yields are the real objectives in all seed potato improvement programs, the development of a uniform tuber type and finer quality in the crop being regarded as largely incidental benefits. Since seed potato improvement is primarily a problem of disease control, the production of certified seed involves a knowledge of the diseases and insects concerned, the damage they produce, their method of spread and the means of control.

While each disease or insect has its own peculiar life history, yet in practice control measures fall largely under four types: general sanitation; seed treatment; spraying; and rogueing.

SEED TREATMENT

Potato diseases which are surface borne can be controlled by seed treatment, if, after such treatment, the tubers are kept clean and planted on clean ground. The surface borne diseases for which seed treatment is recommended are rhizoctonia, blackleg and common scab, and practically all seed potatoes have enough of these diseases to make seed treatment profitable.

Treatment with corrosive sublimate is recommended in preference to cold formaldehyde since the latter is ineffective in controlling rhizoctonia. The usual procedure is to soak the potatoes one and one-half to two hours in the solution; but if the seed is kept moist with water for a day previous to treatment a shorter soaking is effective with less danger of injury. This previous moistening of the tubers softens the black scurf and starts it to grow. It is then easily killed.

To treat in this way, proceed as follows:

1. Moisten the tubers well with a hose, sprinkler, pail or by dipping, being sure to wet every bit of surface. Then cover to keep thoroughly moist for twenty-four hours or at least over night.

2. Soak tubers for 30 minutes to one hour in a solution of corrosive sublimate (mercuric chloride) using wooden barrels or

vats as containers. This solution is prepared by dissolving four ounces of corrosive sublimate in thirty gallons of water. After each two treatments add one ounce of corrosive sublimate to each thirty gallons of water, adding water to maintain the original volume of the solution. If the seed tubers are clean and bags are kept out of the solution it can be used for eight treatments.

3. Dry tubers after treatment as quickly as possible by spreading them on a clean floor or by using crates. After tubers are dry they should be placed in the sun and air for a period of seven to ten days or until thick stubby sprouts are formed, after which they should be placed in good storage until planting time.

Important Points in Seed Treatment

1. Use dormant or slightly sprouted tubers; sprouted tubers may be damaged by seed treatment.

2. Seed treatment should be given at least fifteen days before planting.

3. The temperature of the corrosive sublimate solution and the water used to moisten tubers should be at least 60 degrees Fahr. but not over 80 degrees Fahr. If possible keep the moistened potatoes at a temperature of 60 degrees for the twenty-four hour period.

4. If weather does not permit a rapid drying rinse the tubers in water immediately after treatment.

5. CAUTION: Treated potatoes are poisonous.

If the formaldehyde treatment is to be used, the potatoes should be soaked in the solution for one and one-half hours. The formula recommended for this treatment is as follows:

Formaldehyde (40% solution)	1 pint
Water	30 gallons

Recent experiments conducted by the Iowa State College of Agriculture indicate that a shorter period of treatment can be given with good results. This treatment, known as the Hot Formaldehyde Treatment, is briefly as follows:

Formaldehyde (40% solution)	2 pints
Water	30 gallons

Hold the solution at a temperature of 118-122 degrees Fahr. Soak the seed for two minutes, then remove and keep covered for one hour in piles six to eight inches deep. This treatment is effective against rhizoctonia, blackleg and common scab.

GENERAL SANITATION

The storage house requires attention. Before potatoes are put into storage, all dirt, refuse and rotted potatoes from the previous crop should be removed. Then it should be thoroughly disinfected by sprinkling the floor, walls and posts with a solution of copper sulphate or formaldehyde. Either of the following disinfecting solutions will be satisfactory for this purpose:

(1) Blue stone (copper sulphate) ..... 1 lb.
Water ..... 10 gal.
(2) Formaldehyde (40% solution) ..... 1 pint
Water ..... 10 gal.

Again when seed potatoes are taken out of storage and treated for surface borne diseases, all containers, sacks and tools should be thoroughly washed or disinfected before any of the treated tubers are placed in them. If tools are borrowed from a neighbor, particularly a potato planter, they should be thoroughly disinfected befoe being used. Black leg is known to have been spread in this manner after the seed had been thoroughly disinfected.

Fig. 3. Tip burn, largely resulting from attacks of leaf-hoppers.

SPRAYING

Spraying is effective in the control of early blight, late blight, and tip burn. In addition it is sometimes necessary for flea beetle, Colorado beetle, aphids and leaf hoppers. Further, the use of Bordeaux spray is claimed to have sufficient stimulating effect upon the foliage to justify its use even in the absence of insects and diseases.

The accepted spray schedule calls for an application of Bordeaux mixture at least every ten days, using not less than 100 gallons of solution per acre at each application. A pressure of 225 pounds is desirable and the nozzles should be arranged to cover the entire stem and leaves on all sides with a fine spray mist.

The recognized formula of Bordeaux mixture for spraying potatoes is as follows:

Bluestone	8 lbs.
Stone lime (quick lime)	8 lbs.
Water	100 gal.

For chewing insects, such as the common potato bug, use stomach poisons in the following amounts to each 100 gallons of the above spray material:

Calcium arsenate (powder form)	5 lbs
or Lead arsenate (powder form)	4 lbs.

For sucking insects, such as the common potato aphid, use as a contact insecticide one pint of nicotine sulphate (Black-Leaf 40) to each 100 gallons of Bordeaux mixture.

When nicotine is to be applied alone, use in the following form:

Nicotine sulphate (Black-Leaf 40)	1 pint
Hard soap	4 pounds
Water	100 gal.

For additional information on the subject of spraying, refer to Extension Circular No. 94 issued by the Department of Agricultural Extension of The Pennsylvania State College.

ROGUEING

Spraying and seed treatment are ineffective in the control of several diseases which can only be overcome by eradication, in other words rogueing. There are two types of disease that can be dealt with by rogueing: the virus diseases (Leaf roll, mosaic and giant hill) and the fungus diseases (wilt, blackleg and rhizoctonia). Since the virus diseases are transmissible in the seed and have been extremely outstanding factors in lowering commercial yields, the operation of rogueing is one of the most important features of the whole seed certification program. In addition to the removing of these transmissible diseases, rogueing also takes care of varietal mixtures, off-type plants and weaklings; thus allowing only vigorous and perfect stock to remain as seed producers.

Fields entered for certification are rogued at least three times during the growing season. The first rogueing takes place when

the plants are about 8 or 10 inches high or as soon as any transmissible diseases such as leaf roll or mosaic can be detected. This is probably the most important rogueing of the entire season, because diseased plants are removed from them before insects have had the chance to spread the disease to surrounding healthy plants. On the other hand, if this rogueing is done too early a great many leaf roll plants will be missed because they are not sufficiently advanced to make identification possible. The most serious diseases likely to appear at this time are leaf roll, rhizoctonia and blackleg. Any other plants that are suspicious of being diseased should also be removed. Weak plants may be left until later in the season if so desired.

All rogued plants, especially those affected by virus diseases, should be carried out of the field to avoid transmission of disease from these plants by insect carriers to healthy stock. Similarly, tubers produced by these plants, since they carry the disease, should be removed at rogueing time. Otherwise, they may be dug with the rest and thus defeat the purpose for which the rogueing was intended.

The second rogueing occurs at or near blossoming time. At this period all varietal mixtures can be most easily identified and taken out. The diseases that usually appear at this time are leaf roll, wilt, mosaic, some rhizoctonia and slowly developing cases of blackleg. Some giant hill plants may also be found if the roguer is thoroughly familiar with its early habits of growth.

The third or final rogueing is also important since it is depended on to remove everything missed in previous visits. The diseases most likely to appear at this time are giant hill, leaf roll, wilt and possibly mosaic and rhizoctonia.

A fourth rogueing is sometimes desirable just before the plants die down or immediately after the first light frost, particularly in connection with giant-hill plants which are most easily detected at this time since they remain erect and uninjured by light frosts.

Rogueing is very exacting work, requiring constant concentration and instant recognition of diseased and abnormal plants. Two, or at most four, rows are all that can be covered at one time. It is best to walk very slowly so that nothing will be overlooked. An experienced roguer will not be able to cover more than from five to eight acres in a day; an inexperienced roguer will probably do more thorough work by taking only two rows and walking very slowly, and will in this way cover at most 3 or 4 acres per day. A dull cloudy day is probably the best time

to do rogueing; the diffused light brings out foliage abnormalities more plainly than in harsh, glaring sunlight.

Cultivation sometimes makes rogueing difficult for a day or two, by disturbing the root system and thus inducing a temporary rolling or wilting of the leaves which simulates disease symptoms.

The roguer has to be on his guard against a number of other conditions which might be mistaken for disease symptoms but which are merely the result of local or temporary field conditions.

Fig. 4. Typical Giant Hill (left), and Normal Tuber (right).

To successfully rogue a field of seed potatoes, an intimate knowledge of potato diseases would be highly desirable although not absolutely necessary. Almost any seed grower can readily acquire a working knowledge of the most common diseases by a few hours of study and by making close observation of actual specimens. It is commonly thought that potato diseases are so difficult to detect that only the scientific expert can distinguish them; but if a plant is abnormal in appearance, this fact alone is sufficient to mark it as undesirable as far as seed purposes are concerned. It is therefore not absolutely necessary that a grower be able to definitely identify each disease as long as he is able to distinguish between the normal and the abnormal. In any case an abnormal plant would be classed as an undesirable and removed from the seed crop.

KEY TO POTATO DISEASES

It is fortunate that practically every potato disease has symptoms that can be recognized by anyone without using a microscope, and it is thus possible to arrange these diseases in the form of a "key" which allows one to identify a particular disease with a fair degree of accuracy. The list given in this key does not take into account several minor troubles and insect injuries, but it does include all the common potato diseases.

How to use the Key.—Look through the main headings given under the Roman figures I, II and III, and decide from the symptom in which group it falls. Then in that group read over all the sub-headings given under a single letter or sign to find the correct sub-group. Proceed in the same way with this sub-group till the name of the disease is found. In order to employ the key to best advantage it is well to use a very typical specimen, or better still, several representative specimens.

Always bear in mind that two or more diseases may be present on the same plant as tip burn and early blight, or leaf roll and rhizoctonia, or scab and late blight rot. Cases where two virus diseases occur on the same plant are not uncommon and are very puzzling.

I. The diseased condition affects the tops (best seen at blossoming time or shortly after).

A. The principal symptom is a dying or browning of leaf tissue.

1. Brown spots scattered: the larger with concentric rings ..... **Early Blight.**
2. Killed areas large, often whole leaves and plants: associated with recent moist weather ..... **Late Blight.**
3. Killing mainly at tips and edges: associated with recent hot dry weather, and usually with leaf hoppers ..... **Tip Burn.**

B. The principal symptom is some abnormality in color or shape of foliage.

1. Occurs on scattered plants, the rest normal and vigorous.
   (a) Underground stem normal.
      I. Plants normal in size or slightly dwarfed.
         A. Leaves, especially the lower, rolled; leaf margins even ..... **Leaf Roll.**
         B. Leaves slightly folded, margins crinkled.
            1. Angles of stem and leaves normal ..... **Crinkle Mosaic.**
            2. Angles of stem and leaves very narrow ..... **Spindle Tuber.**
         C. Leaves mottled.
            1. Surfaces even ..... **Mottle Mosaic.**
            2. Surfaces uneven or rugose ..... **Rugose Mosaic.**
      II. Plants rank in growth and oversize ..... **Giant Hill.**
   (b) Underground stems discolored externally or internally.
      I. Externally sound but woody tissue browned ..... **Wilt.**
      II. Visible external discolorations.
         A. Stem with brown lesions ..... **Rhizoctonia.**
         B. Stem with black rot ..... **Blackleg.**
2. All the plants in the field or in a definite area are yellowed or sickly, showing poor spindly growth, yellow color or leaf folding ..... **Effects of water, heat, drought or starvation.**

II. The diseased condition is noted in the stalks at or near the ground level.

A. Found about blossoming time or shortly after.

1. Symptom externally visible as a rot or discoloration.
   a. Rot deep, often clear through stem, and charcoal black in color ..... **Blackleg.**
   b. A brown discoloration or rot varying from small superficial spots to complete destruction of stem tissue ..... **Rhizoctonia.**
2. Symptom only seen by cutting stem, as a darkening of the woody tissue. (Compare with healthy stem)
   a. Woody tissue browned when stalk is cut across.

I. This condition only in lower part of stem ..... **Fusarium Wilt.**
II. The browned condition extends well up into the leafy stem ..... **Verticillium Wilt.**
b. Woody tissue when cut across shows black spots or dots ..... **Bacterial Wilt.**
3. Symptom is cauliflower-like growth at or near the ground surface ..... **Wart.**
B. Found in early stages, about the time plants appear above ground.
1. Misses or late plants.
a. Sprout with black charcoal rot ..... **Blackleg.**
b. Sprout with brown dead areas or brown-rotted at top ..... **Rhizoctonia.**
2. Plants appearing at normal time but developing sickly yellow or wilted tops
a. Stem below ground with brown dead lesions ..... **Rhizoctonia**
b. Stem below ground with black charcoal rot or with tubers also thus rotted ..... **Blackleg.**

III. The symptoms are observed on the tubers.

A. Symptoms are externally visible.
1. Form of tuber abnormal.
a. Warty outgrowths from eyes, or tuber replaced more or less by cauliflower growth ..... **Wart.**
b. Tubers dumbbell shape or with knobby outgrowths ..... **Second Growth.**
c. Tubers elongated or spindle shaped ..... **Spindle Tuber.**
2. Form of tuber normal.
a. Skin spots of small size; flesh normal.
aa. Dark flecks, merely adherent to skin, turning deep dull back when wetted ..... **Rhizoctonia.**
bb. Scab spots on surface.
aaa. Spots brown, rough, usually open, and scab tissue corky in texture ..... **Ordinary Scab.**
bbb. Spots brown, typically covered, showing brown powder when rubbed (rare) ..... **Powdery Scab.**
b. Skin with silvery spots or areas, usually developing after storage, and associated with withering, but not rotting of the tubers ..... **Silver Scurf.**
c. Rot areas are noted involving the flesh below.
aa. Wrinkling and rotting of stem end (infection takes place in field) ..... **Stem End Rot.**
bb. Rot following bruises or cuts after storage ..... **Dry Rot.**
cc. Purplish or dark irregular areas with brown indefinite rot in flesh beneath (best seen on washing) ..... **Late Blight.**

B. The symptoms are internal in the flesh of the tuber
1. A rot of the flesh.
(a) Met in the field or in the first two weeks of storage
(aa) Rot advances into tuber with uniform, even front.
(aaa) Rotted flesh discolored.
Begins at stem end
Brown rot, dry or jelly-like, skin wrinkled ..... **Stem End Rot.**

Black slimy charcoal rot in heart .. .. **Blackleg.**
Begins at wounds, cuts or bruises ..... **Dry Rot.**
(bbb) Rotted flesh scarcely discolored, soft and pulpy, associated with wet conditions ..... **Bacterial Rot.**
(bb) Rot advances unevenly in brownish streaks or areas ..... **Late Blight Rot.**
(b) Met in later storage.
(bb) Rot wet
(bbb) Pulpy with undarkened flesh ..... **Bacterial Rot.**
(ccc) Rotted flesh firm and darkened ..... **Active Dry Rot.**
(cc) Rot dry
Advancing with uniform front into tissue ..... **Inactive Dry Rot.**
Internal front of rot irregular ..... **Late Blight Rot.**

2. Not a rot.
a. The symptom is some discoloration of the flesh.
aa. When a slice is taken from stem end discolored dots are seen, indicating a ring of fibrous discoloration extending from stem into the tuber ..... **Stem End Browning.**
bb. Net-like system of brown discolored lines in flesh generally, but often near the skin ..... **Net Necrosis.**
cc. General darkening of flesh, often of heart, usually met with in late winter or spring; tubers darken quickly on peeling ..... **Blackheart.**
b. There is an open space in the center of the tuber, with the flesh often somewhat discolored about it ..... **Hollow Heart.**

DISEASES AFFECTING SEED CERTIFICATION

TIP BURN OR HOPPERBURN

Symptoms.—The leaf parts affected by tip burn are usually confined to the margin and tip of the leaf, and show as distinct irregular brown dead areas. (Fig. 3.) These areas are dry, harsh and brittle with the affected part of the leaf tending to turn upward and inward. Such injury works inward from the margin and tip of the leaf and may finally involve the entire leaf, or even the entire leaf petiole. It is most severe during dry hot weather and especially when accompanied by severe attacks of leafhoppers.

The losses incurred by Pennsylvania potato growers due to tip burn will vary from year to year; the U. S. Plant Disease Survey in 1919 estimated that the loss was approximately 4,300,000 bushels or 15% of the total crop.

Control.—The efficient and thorough spraying methods practised by seed growers reduce the injury from tip burn to a minimum, since Bordeaux mixture acts as a repellant to the leafhoppers which are largely responsible for this injury. It is also thought that Bordeaux protects against rapid transpiration by its shading effect.

EARLY BLIGHT

Symptoms.—Early blight is a fungus disease and appears as definite spots scattered over the surface of the leaf. Such spots are dry and brittle and more or less circular in outline, measuring from $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter, except when two or more spots coalesce. These spots may appear on any portion of the leaf and are usually patterned with a series of dark or even black concentric rings, giving the spots a target-board effect. Early blight is most severe when hot weather periods alternate with moist weather.

Control.—Early blight is a minor disease in seed certification; the standard Bordeaux spray universally applied by seed growers will control it effectively.

LATE BLIGHT

There is probably no other disease which is as devastating on the potato crop as late blight. It occurs periodically in all potato producing sections when favorable conditions of temperature and moisture exist for infection. Entire fields are frequently destroyed by this disease. The severest loss sustained in recent

years occurred in 1920, when it was estimated that 25% of the Pennsylvania potato crop was lost through late blight. Our seed producing sections are especially liable to late blight because the cool moist climate of these sections is favorable to blight infection. Certified seed growers encounter practically no loss from this disease.

Symptoms.—The disease appears on the foliage as more or less circular water-soaked areas which are first found at the tip or edge of the leaf, although infection may occur on any part of the

Fig. 5—Left: A tuber rotted in the center by blackleg. Center: Tuber affected by late blight, largely dried up in storage. Right: Section of potato showing the irregular brown pentration of late blight rot.

leaf or stem. When the infection is light, the leaves on the lower part of the plant or those near to or resting on the ground are usually the first to show signs of the disease. The leaf parts affected show a definite grey mildew around the border of the infected area on the under surface of the leaf. Late blight is very severe during moist, cloudy weather when the temperature registers from 70 to 74 deg. Fahrenheit. Severe attacks on the foliage are accompanied by a characteristic rank, foul odor.

On the tuber the first symptom of the disease is an irregular purplish discoloration, underneath which the rot penetrates as brownish irregular streaks, advancing into the tuber in an indefinite manner (Fig. 5). In cool storage the rot ceases and affected areas become sunken and dry. The mushy rot which frequently is found in connection with late blight rot in the field is brought about by secondary infection by bacteria or fungi.

Infection takes place when the tubers come in contact with spores which are produced on the foliage by the grey mildew

mentioned above. During rains these spores are washed into the soil and infection takes place; infection may also take place at digging time when the tubers come in contact with the infected vines. When infection takes place at digging time the rot will not appear until later in the storage period when it will show as the dry rot mentioned above (Fig. 5).

Control.—Late blight can be successfully controlled by thorough timey and efficient spraying with Bordeaux mixture (See p. 20),

While the commercial grower is interested in protection against late blight from production standpoint, the center of interest in seed certification is the effect of blight in obscuring field disease as well as in its possible effect as a tuber rot developing after digging time. For this reason spraying should continue late in the fall, even after the leaves on the plants have died. This will prevent a delayed infection of late blight on the stem of the plants which often remain green until digging time. Such infection will be sufficient to carry over and infect the tubers at digging time and result in considerable loss to the grower after the stock has been placed in storage. Delayed infection of this type cannot be detected until after the tubers show it in the form of a rot. If seed from such fields were to be sold in the fall it would be impossible for either the seed grower or the buyer to determine its presence until after the tubers had started to rot. This would result in considerable trouble and loss to the seed grower. In the event that an infection of late blight should appear earlier in the growing season, its presence would be readily determined by the inspector. Seed from such fields would then be refused certification, except when only a trace of late blight is found, in which case the seed grower is required to store the seed until spring before he is permitted to dispose of it as seed stock. Certification will then be granted if the stock came through the storage period in satisfactory condition.

LEAF ROLL

Symptoms.—Plants affected by leaf roll show a rolling of the leaves with the edges and tips turning upward and inward on the midrib, giving the leaf a spoon shaped appearance (Fig. 6). Leaves rolled in this manner are coarse, leathery and harsh to the touch. Such leaves are also brittle, and break when squeezed in the hand. The leaves of affected plants are light greenish-yellow in color and sometimes have a slight purplish or bronzed discoloration. Affected plants are distinctly dwarfed, with a rigid, staring upright habit of growth. Such plants are very susceptible to tip burn.

The tubers from leaf roll plants are usually fewer in number, small, and set very close to the main stem. The yield from leaf roll plants is greatly reduced. Leaf roll is probably the most serious potato disease that we have to contend with in the production of certified seed. The annual losses to the Pennsylvania potato industry from leaf roll, range from 10% to 15% of the entire crop. Fields are quite frequently encountered that show from 75% to 100% of the plants affected by the disease. Such fields rarely produce much more than a third of a crop.

Fig. 7. Leaf roll plant; the upright habit and rolled leaves are characteristic.

Control.—Since leaf roll belongs to the virus group of diseases, its cause is unknown; it is perfectly certain, however, that the disease is transmitted by the tubers; that an affected plant never recovers; that it is spread from plant to plant by aphids; and that spraying or seed treatment are useless except in so far as they control plant lice. From the above it follows that eradication of diseased plants by rogueing is the only practical method by which a field of seed potatoes can be freed from leaf roll. Further assistance in control can be obtained by keeping the field under vigorous, healthy growing conditions so that diseased plants can be readily distinguished; by isolation of the field from diseased

stock to avoid insect transmission; and by the control of the plant lice which are known to spread leaf roll.

While leaf roll can hardly be eliminated from the commercial crops of the State, the climatic conditions in the seed districts appear to be less favorable to the spread of leaf roll than the climate in other parts of the state, so that by a system of careful inspection and rogueing seed can be produced in these districts practically free from leaf roll. Since certification work was undertaken the percentage of leaf roll has fallen markedly in the seed producing areas, and there is every promise that these areas will come to be a permanent adequate source, for the whole State, of seed practically free from this crop reducing disease.

MOSAIC

Being also a virus disease, mosaic is in nature and method of spread similar in many respects to leaf roll. While it is also common throughout Pennsylvania, it is not as prevalent nor so dam-

Fig. 7. Mosaic (right) and healthy plant (left). The rugose type of mosaic is here evident.

aging as leaf roll. In the warmer sections of the state mosaic plants yield very poorly and stocks containing a high percentage of the disease deteriorate or "run out" rapidly. Several apparently distinct types of mosaic have been described, but since their method of spread and means of control are essentially alike, they are not considered individually under our certification standard, but are classed together under the common term "mosaic."

Descriptions of as many as five or six types of mosaic have been given in various parts of U. S. and Europe; there are three

main types which are readily recognizable in Pennsylvania fields: mottled mosaic, rugose mosaic, and crinkle mosaic.

Mottled Mosaic.—As the name indicates, the foliage is mottled by indefinite areas of yellow-green interspersed with areas of normal color. This mottling is at best not striking, and is most easily seen in dull cloudy weather. Typically, this condition is not accompanied by rolling of the leaves or crinkling of the leaf edges, although it is sometimes found associated with other types of mosaic. Affected plants tend to turn yellow and die prematurely. This type of mosaic is readily obscured by hot, dry weather. It has often been referred to as "mild mosaic."

Rugose Mosaic.—In this type, the most constant symptom is an uneven or rugose leaf surface, caused by underdevelopment of the veins in comparison with the leaf tissue. This brings about

Fig. 8. Mosaic; a healthy potato leaf and two leaves showing rugose mosaic.

convolutions in the leaf surface, accompanied by a turning down of the edges of the leaf. Since the leaf petiole and internodes are also underdeveloped the plant has a characteristic dwarfed and round appearance (Fig. 7 and 8). Rugose mosaic is invariably accompanied by mottling of slight or evident character. Such plants are extremely susceptible to tip burn, turn yellow early and die prematurely.

Crinkle Mosaic.—In crinkle mosaic the leaves are folded upward and all of them have wavy margins. The plant has a staring, upright habit of growth due to the leaf stems and petioles being set

at a sharper angle than normal. Mottling may be present in this type of mosaic but is usually more obscured. Tubers are set close to the stem as in leaf roll.

The outstanding distinction between crinkle mosaic and leaf roll is in the wavy margin of the leaves which is absent in leaf roll.

Control.—Since all these types of mosaic are known to be spread in the same manner as leaf roll and other degenerative diseases, control involves careful rogueing, isolation of seed fields and the control of plant lice.

GIANT HILL

Symptoms.—The leaves of giant hill plants are usually glossy and coarse with slightly roughened elevations between the veins. The plants are extremely large and rank growing with numerous lateral branches on the main stems. Such plants often remain in blossom later than normal plants and frequently remain uninjured by light frosts. Root systems of giant hill plants are usually fibrous and heavy. The tubers produced are frequently very large with only one or two to a hill. Such tubers show prominent shoulders back of the eyes (Fig. 4). All the characteristic symptims of giant hill are those of excessive vegetative growth.

Giant hill is a comparatively new potato trouble in Pennsylvania and has been recognized as a distinct type of degenerative disease only within the last few years. It is prevalent in the potato fields of the state, and is coming to be recognized as an important factor in the commercial crop as well as in the seed districts on account of the decided reduction in yield which affected plants exhibit.

Control.—Rogueing as for leaf roll and mosaic is the only control known; from the results of two seasons' work this method appears to be effective. Since giant hill plants are easily recognized after normal plants have been slightly frosted or have started to die down, it is sometimes advisable to give a field an additional late rogueing in order to free it entirely from this disease.

SPINDLE TUBER

Symptoms.—The most characteristic symptoms of this disease are seen in the tubers which are more elongated and more rounded in cross-section than is normal for the variety. Spindle tuber plants are somewhat dwarfed and have an upright staring habit of growth. The branches, petioles and leafstalks are all set at a sharp angle and the leaflets, instead of spreading out flat, form a V-shaped trough with the midrib. This condition often causes the last pair of leaflets to overlap the terminal one.

Control.—Being a disease of the virus group, the only known control is through the rogueing methods used for mosaic and leaf roll.

RHIZOCTONIA

Symptoms.—Rhizoctonia is a soil-borne fungus disease which affects potato plants in four definite ways. The fungus winters either in the soil or as the familiar "black scurf" on the tubers

Fig. 9. Rhizoctonia causes a damping-off in cold wet soil in spring resulting in late plants or misses.

(Fig. 2). When a tuber bearing the black scurfy sclerotia is planted the fungus starts into life with the germination of the tuber and attacks the sprouts, which are killed off or badly injured by the brown lesions that the parasite causes (Fig. 9). It is worthy of note that it is the tuber borne sclerotia and not fungus in the soil itself that is thought to be responsible for early shoot injury; and it is common knowledge that sprout girdling is worst in cold, wet soils.

Attacks on the underground stems later in the season may partially or completely girdle the stem.

The upper leaves of plants affected by rhizoctonia have wavy edges which tend to turn upward, giving the upper part of the plant a crinkled or rosetted appearance. There is also a slight yellowing along the margin and tip of the crinkled leaves, while

Fig. 10. Rhizoctonia injury in summer. Girdling of the underground stem causes rolling and yellowing of the leaves.

the lower leaves of the affected plants usually roll up in a cigar shaped fashion (Fig. 10). Such plants are usually normal in size, except when the attack on the underground parts is severe enough to destroy the plant entirely. Enlarged nodes and aerial tubers are very common on infected plants; this condition however is only found when the lesions on the underground parts are quite severe and extensive. Plants affected late in the season often produce a very large number of small tubers. Such plants often blossom later than normal plants.

Attacks of rhizoctonia on the young tubers causes a russeting of the skin which may develop roughened cracks that are disfiguring or may produce definite deformation.

In the cool weather of fall the fungus forms the familiar black scurfy masses on the surface of the tubers. These stand out clearly when the skin is wetted. The sclerotia are entirely superficial and do no harm to the tuber, but they serve to carry the fungus over winter, and if present in appreciable numbers they disfigure the tubers.

The rhizoctonia disease is quite general in Pennsylvania and causes an estimated annual loss of up to 5% of the state's total potato crop. Although this trouble is not a serious one among certified seed growers, it is doubtful if the annual loss due to rhizoctonia is entirely appreciated, particularly during a cool, wet planting season.

Control.—The summer occurrence of rhizoctonia is not as serious in most sections of Pennsylvania as in more northern potato areas; a good long rotation is helpful in reducing the amount of the fungus which, however, is present in nearly every type of soil. The seed borne sclerotia can be prevented from causing injury at germination time by seed treatment which has been largely developed with this purpose in view.

Any plants affected by rhizoctonia during the summer are removed from the seed fields. Likewise, tubers which are disfigured by this disease are eliminated in grading.

WILT

Wilt is a soil-borne fungus disease; the fungus is prevalent in all soils and makes its first attack on the rootlets from which it penetrates into the stem. When this takes place the woody tissue of the stem below ground becomes browned and discolored and sap conduction is seriously interfered with. Both the destruction of the rootlets and clogging of the stem induce drought symptoms in the top when water becomes scarce.

Symptoms.—The upper leaves of infected plants are lighter in shade than normal, with those around the base of the plant showing a distinct yellowing. This conditioin is usually followed in a few days by a wilting of the stalks or plants affected, often resulting in the premature death of the plant. Wilting most always occurs during the hottest part of the day, and is most frequently found during periods of drought.

Tubers from such plants also show a brown discoloration of

the vascular tissue when cut across the stem-end (Fig.11). Vascular discoloration of the stem and tuber is not a positive indication of the presence of this disease unless it is accompanied by a pronounced wilting of the plant. This disease is most frequently found at or near blossoming time.

Control.—Since fusarium wilt is so widely spread and so closely bound up with soil conditions the most satisfactory control meas-

Fig. 11. Stem end browning which may be the result of wilt.

ures involve a good crop rotation, a plentiful supply of humus which will maintain uniform moisture content, and the planting of wilt free seed. Where these conditions are maintained the small amount of fusarium wilt that develops is easily taken care of by rogueing.

Owing to the fact that wilt is a hot weather disease, its elimination from seed field is likely to take place at the second and third rogueing.

BLACKLEG

Symptoms.—Blackleg is a bacterial disease carried on the seed tubers from which it is able to attack the young growing stems. If this attack is early and severe the shoots are killed outright and a miss results. When stem girdling is slow and gradual the plant grows in a dwarfed, yellowed condition with upright leaves often closely folded. The characteristic girdling at the base of the stem has a charcoal black color penetrating into the central

tissues or pith. The organism also causes a slimy, black rot in the tubers, usually in the central part but starting in from the stem. (Fig. 5.)

All evidence indicates that the blackleg organism is not carried over winter in the soil but that contaminated seed is the source of infection. It is often found in northern seed but tends to disappear after this has been grown in our state for a couple of years.

Control.—Blackleg tends to eliminate itself to a large extent because so few of the affected plants set any tubers. When those which do so are rogued out in summer the disease becomes unin-

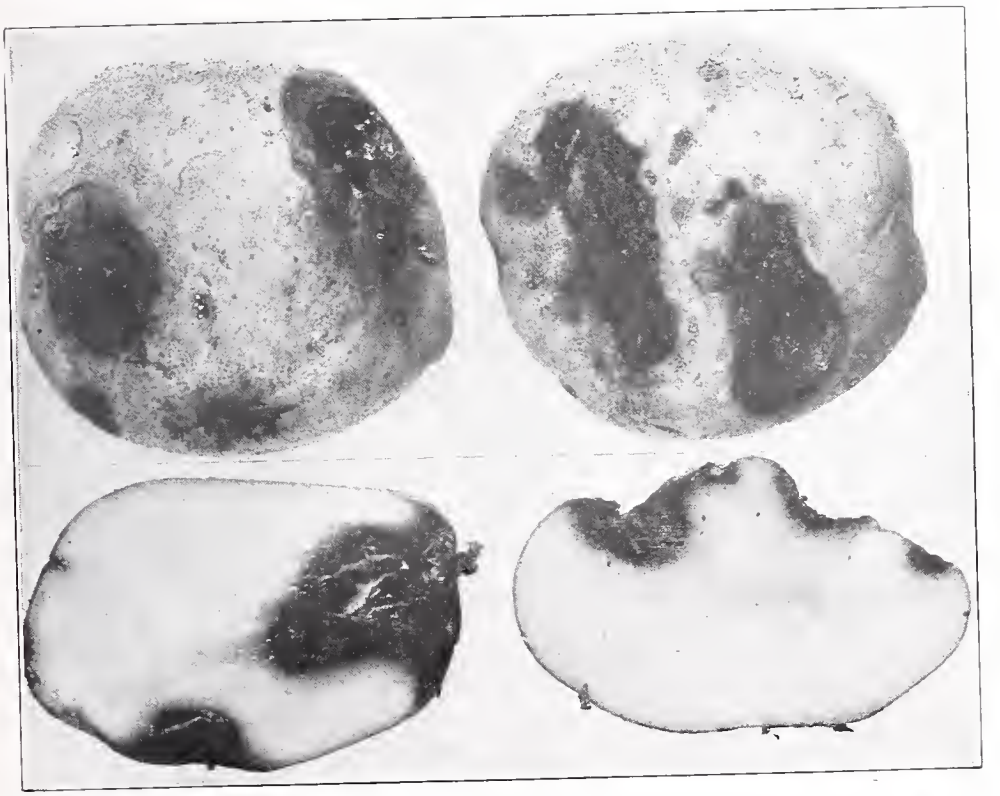

Fig. 12. Fusarium storage rot; below, the same tubers cut to show deep penetration of the rot.

portant. Seed treatment is quite effective against blackleg, since it destroys the bacteria which have been smeared over the surfaces of tubers in the process of digging, handling and grading.

STORAGE ROT

Storage rot is favored by warm, moist conditions. It is due to any one of a number of rot organisms, which enter the tuber by way of bruises, cracks or wounds or which follow a late blight infection. (Fig. 12.) Many of the storage rots are classed as

"dry" rots because in later storage the rotted tissue may dry out and become soft and powdery. (Fig. 13.) In reality, however, the dryness of the rot depends largely on air moisture; when rotting commences in very moist air, or deep in the tissues where the rot is advancing, the tissues are moist.

From the point of entry these storage rot organisms invade the flesh in a uniform even front and may thus be distinguished from late blight rot where the advance takes place quite irregularly in streaks or indefinite brown areas.

Under certain conditions storage rots may cease activity and the tuber may wall off the rotted tissue with a skin-like layer. We may thus speak of a storage rot as being active or inactive at any given time.

Since these organisms apparently cannot penetrate the unbroken potato skin, it is important to have potatoes go into storage uninjured or to put them into storage only after they have been kept long enough in a dry atmosphere so that every

Fig. 13. Fusarium storage rot; the rotted portions have been kept in fairly dry conditions and have dried out and shrivelled.

wound or cut has been healed perfectly and has formed what amounts to a new skin over the injured portion. Potatoes with dry rot are excluded from certified seed under the grading requirements. If planted they are likely to rot before germination takes place, especially if the soil is cold and wet. Rotted tubers are thus likely to produce misses or very weak plants and do not make good seed.

Seed treatment is of no value on tubers affected by dry rot.

BACTERIAL SOFT ROT

A soft pulpy rot which causes little or no discoloration of the tissues is often found in potatoes associated with very wet con-

ditions. It may occur in the field in fall in wet soil, and tubers which are affected often have pronounced development of the lenticels indicating that in the waterlogged soil air was lacking. Bacterial rot frequently follows late blight infections and destroys the tuber. Frosted tubers also are decomposed by bacterial rot and if storage conditions are very moist and temperature high bacterial rot may occur along with other storage rots. This type of rot is also common in wet seasons in spring, causing a rot of the sets.

STEM END ROT

Symptoms—Stem end rot is typically a disease of the field in late summer. The rot is due to a fungus (Fusarium) closely allied to the one which causes wilt. In wilt attacks the stem end of the tuber may be browned or discolored but the stem end rot organism produces a real rot which starts at the stem and involves more or less of this end of the tuber. At first it produces a soft rot, the tissue becoming watery and brown and having the texture of jelly, whence arises the common name of "jelly end rot." Later the rotted flesh dries up and the skin wrinkles over it in characteristic fashion.

Control.—From the standpoint of seed potato certification, the disease is of little importance since it can be eliminated from the stock by grading and seed treatment.

Potatoes with stem end rot are very hard to store successfully.

SCAB

Potato scab is the most common disease of the potato. (Fig. 2.) It has been called variously, scab, scurf, spot and rust, but in order to distinguish it from other diseases it seems advisable to call it common scab. While scab is considered of small importance on account of its being a surface disease, yet it not only makes the tubers unsightly and thus lowers their sale price, but also lessens the food value because of the deeper peeling that must be taken to get below scab spots.

The scab organism is present almost everywhere in our soils, but is most prevalent in lime or clay soils, which are alkaline in reaction. Muck or sand soils being acid in nature have relatively little scab.

A scabby crop of potatoes may result from either growing in a soil naturally infested with scab or from planting scabby potatoes which carry with them in the scab spots infection for the new crop. If the soil is free from scab, seed treatment will be effective, but this treatment will be disappointing if the soil is

already badly infested with the scab organism. On the other hand, in very acid soils potatoes are unlikely to develop much scab whether treated or not. Seed treatment is recommended only for soils which are not acid enough to discourage scab if introduced on the seed, nor yet alkaline enough to be badly infested naturally. Many soils belong to this intermediate class.

The use of fresh barnyard manure at time of planting has a strong tendency to increase scab, for though manure slightly increases soil acidity this effect is more than counterbalanced by its providing food for multiplication of the organism. It is advisable to use well rotted manure for potatoes or else put it on in the fall and plow under so that it will be well rotted when potatoes are planted.

The use of lime or ashes favors scab by increasing alkalinity. Plowing down green manures and the use of proper fertilizers will help to overcome the disease when the crop is not heavily infected. Half of the nitrogen applied should be derived from sulphate of ammonia since this fertilizer tends to leave the soil in an acid condition.

Crop rotation is important wherever scab is a problem; the scab developed by a potato crop tends to die out after several years under other crops which are not susceptible.

Scab is of importance in seed certification from three points of view: injury to eyes, the carrying over of the organism on the tubers, and the unfavorable appearance that results when scab is severe. Because of these features the grading standards permit only a small percentage of scab and this must be of inconspicuous type so that the eyes are not harmed nor the appearance injured.

HOLLOW HEART

Symptoms.—This condition is usually the result of too rapid development of the tuber during the growing season. It is quite frequently encountered in crops that were subject to an excessive amount of moisture, following a period of dry weather.

Hollow heart appears as an irregular shaped brown cavity in the center of the tuber. The inner walls of the cavity are lined with brown granular tissue or dead cells. (Fig. 14.) This condition is most frequently found in tubers that tend to be large or over-sized and is determined while the potatoes are quite young.

Hollow heart apparently has no effect on potatoes from the point of view of seed, but largely for the sake of appearance it is eliminated from certified seed as far as possible, especially in connection with large sized tubers.

Control.—Hollow heart can be almost entirely eliminated by closer planting and by thorough cultivation. Closer planting tends to produce a more uniform medium sized tuber and should be accompanied during periods of drought by more frequent shallow cultivations. This measure conserves the moisture in the soil and enables the potato plant to make a more uniform growth throughout the growing season.

Fig. 14. Left: Hollow heart; Center: A tuber with the upper end frozen; Right: Darkening of the flesh due to low temperature.

BLACK HEART

This condition is frequently found in potatoes that have been stored in poorly ventilated and high or low temperature storage. It appears as black irregular areas of dead tissue in or near the center of the tuber (Fig. 14). Black heart can be avoided by storing potatoes under more favorable conditions of temperature and ventilation. Potatoes stored under conditions which produce black heart are not considered eligible for certification.

FROST NECROSIS

Frost necrosis is frequently found in tubers that were exposed to light frosts before being placed in storage. It appears as a dark-brown or black ring ⅛ inch in width and about ⅛ inch

beneath the surface of the tuber. Frost injury may also appear as a netting of the entire flesh of the tuber. Potatoes exposed to heavy frosts or low temperature will show a rotting of the exposed tissue in a very few days. (Fig. 14.) Tubers that have been chilled, however, do not break down completely but show the injury described above. Such stock will usually germinate and grow but it cannot be expected to be as vigorous and productive as uninjured seed, and is therefore not allowed to go out as certified seed.

SPINDLE SPROUT

The cause of spindle sprout is not completely understood, and there are several factors that seem to be responsible for this condition. Spindle sprout, as the name implies, appears as slender, weak sprouts on apparently normal and healthy tubers. This condition is often found in potatoes that were produced under adverse growing conditions, particularly in stock that was subject

Fig. 15. Tubers affected by potato wart.

to an extended period of heat and drought near the end of the growing season. Improper storage and excessive sprouting are also thought to produce this condition.

The presence of spindle sprouts would seem to indicate that the tuber is in a weakened or devitalized condition; such tubers are unable to produce a normal healthy top. Tubers showing spindle sprouts should not be used for seed purposes under any conditions. Poor stands and reduced yields are certain to result.

POTATO WART

Symptoms.—Potato wart is due to a soil-borne organism of low type which attacks the tuber and underground parts. These parts are not killed but the stimulation caused by the fungus

results in the formation of great or small lumps of wart-like tissue, the general appearance of which suggests a cauliflower. (Fig. 15.) There are no outstanding symptoms in the tops. When the attack is severe some or all of the tubers are replaced by rough irregular masses of warty tissue. Affected tubers are not injured for food but soon rot in storage. The wart disease has been known since 1918 in several of the coal mining towns both in the anthracite and bituminous coal districts. It has never been found in farms and every effort is being made by quarantine restrictions to keep it from spreading into agricultural areas. (See Pennsylvania Department of Agriculture Bulletin 394.)

Control.—Since the disease is closely bound up with the soil and the tubers it is likely to be spread largely by seed or table stock potatoes grown in infested soil or in manure from the coal mining towns where wart exists. Seed potato growers will do well to avoid with greatest care any traffic of a kind likely to introduce wart into their land, for if wart is found quarantine restrictions are inevitable.

The only practical control for wart lies in growing immune varieties, of which there are several; those most adapted to Pennsylvania are Irish Cobbler, Green Mountain, and Spaulding Rose. The Rural New Yorker and Russet Rural types so generally grown are quite susceptible to wart. The table of varieties on page 12 gives the relation of all the best known potato varieties to the wart disease.